

Analysis of Rapidly Developing Low Cloud Ceilings in a Stable Environment

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Forecasters at the Space Meteorology Group (SMG) issue 30 to 90 minute forecasts for low cloud ceilings at the Space Shuttle Landing Facility (TTS) to support Space Shuttle landings. Mission verification statistics have shown ceilings to be the number one forecast challenge for SMG. More specifically, forecasters at SMG are concerned with any rapidly developing clouds/ceilings below 8000 ft in a stable, capped thermodynamic environment. Therefore, the Applied Meteorology Unit (AMU) was tasked to examine archived events of rapid stable cloud formation resulting in ceilings below 8000 ft, and document the atmospheric regimes favoring this type of cloud development.

The AMU examined the cool season months of November to March during the years of 1993–2003 for days that had low-level inversions and rapid, stable low cloud formation that resulted in ceilings violating the Space Shuttle Flight Rules. The AMU wrote and modified existing code to identify inversions from the morning (~10 UTC) Cape Canaveral, FL rawinsonde (XMR) during the cool season and output pertinent sounding information. They parsed all days with cloud ceilings below 8000 ft at TTS, forming a database of possible rapidly-developing low ceiling events. Days with precipitation or noticeable fog burn-off situations were excluded from the database. In the first phase of this work, only the daytime hours were examined for possible ceiling development events since low clouds are easier to diagnose with visible satellite imagery. Phase II of this work includes expanding the database to include nighttime cases which is underway as this abstract is being written.

For the nighttime cases, the AMU will analyze both the 00 UTC soundings and the 10 UTC soundings to examine those data for the presence of a low-level inversion. The 00 UTC soundings will probably not have a surface-based inversion, but the presence of inversions or “neutral” layers aloft and below 8,000 ft will most likely help define the stable regime, being a thermodynamically “capped” environment. Occurrences of elevated low-level inversions or stable layers will be highlighted in conjunction with nights that experienced a possible development or onset of cloud ceilings below 8,000 ft. Using these criteria to narrow down the database, the AMU will then use archived IR satellite imagery for these possible events.

This presentation summarizes the composite meteorological conditions for 20 daytime event days with rapid low cloud ceiling formation and 48 non-events days consisting of advection or widespread low cloud ceilings and describes two sample cases of daytime rapidly-developing low cloud ceilings. The authors will also summarize the work from the nighttime cases and describe a representative sample case from this data set.

For the daytime cases, the distinguishing factor between the event and non-event days appears to be the vertical wind profile in the XMR sounding. Eighty-five percent of the event days had a clockwise turning of the winds with height in the lower to middle troposphere whereas 83% of the non-events had a counter-clockwise turning of the winds with height or negligible vertical wind shear. A clockwise turning of the winds with height indicates a warm-advection regime, which supports large-scale rising motion and possible cloud formation. Meanwhile, a counter-clockwise turning of the winds with height indicates cold advection or sinking motion in a post-cold frontal environment.